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The Supply Responsiveness of Small Kenyan Cotton Farmers

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Cotton is critically important to the economy of Kenya. The manufacturing industry uses it extensively for the production of vegetable oil; small farmers depend upon it for a major source of their farm income; and the government recognizes it to be a potentially large earner of foreign exchange. Cotton has been cultivated in Kenya for hundreds of years, but production has remained low despite an escalating demand. Production shortfalls have been traditionally met by imported supplies from Kenya's neighboring countries of Uganda and Tanzania. However, political instability in these countries coupled with their deteriorating trade relations with Kenya has caused great uncertainty regarding the reliability of future supplies. Establishing trade relations with other non-neighboring countries for the importation of cotton is considered uneconomical because of the tremendous transportation cost associated with the bulky commodity. Hence, the government of Kenya embarked upon an economic policy to increase cotton production to self-sufficiency.

The economic policy of the government was launched in 1976 as the Cotton Development Program (CDP), oriented and implemented to increased cotton

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production among small farmers. Components of the program included interest free capital, free planting seeds, and a substantially increased farm gate price for cotton. In essence, the program consisted of a combination of input subsidies and product price guarantees. These incentives were enough to almost double cotton production in the short period of three (3) years. Production increased from 35 thousand bales in 1977 to a 1979 total of 62 thousand bales (Figure 1). Production increases not only met domestic demand but also provided an annual surplus of 10 thousand bales which were exported to generate much needed foreign exchange. Since 1979, production has fallen to approximately 40 thousand bales while demand has risen to 70 thousand bales annually. This decline in production has occurred despite a continuation of many of the incentives of the CDP.

As production declines, the cotton industry in Kenya is confronted with instability of supplies coupled with low production levels. These problems erode much needed foreign exchange and create considerable uncertainty among farm producers and policymakers as to the future outlook for cotton as an enterprise. Economic planners are uncertain as to whether abrupt changes in production are due to relative price changes among commodities or to other problems beyond the farm gate. This study is therefore intended to (1) identify and empirically estimate those factors which determine cotton production; (2) examine the relative impacts of these factors; (3) and offer suggestions and/or policy recommendations for increasing cotton production.

Theory and Methodology

Economic theory suggests that the planting decision of a farmer is based on the price expected for output, the price expected for substitute crops, the cost of factors of production, the production capacity of the farmer, and the riskiness of the enterprise.[1] Neoclassical microeconomic theory further assumes that farmers' profit functions are homogenous of degree one and their input demand functions are homogenous of degree zero in prices.[2] These conditions indicate that any specified supply function should express commodity prices in real terms.

Theory also assumes that farmers or other decisionmakers possess full information regarding the consequences of alternative economic decisions. Econometric supply investigators, however, recognize an inconsistency between this theoretical assumption and real world phenomena. Econometricians therefore distinguish between static and dynamic behavior systems. Modelling of dynamic behavioral relations recognizes the lag effects of economic behavior, particularly those which exist between output levels and prices.[3]

General economic theory does not suggest a particular functional form for supply relationships. The relationship may take a linear or non-linear form depending on the explicit relationship between the dependent and explanatory variables. Typical supply response models have been expressed in linear form with linear time trends to capture technological changes.[4-6] A linear relationship is often a good approximation since it is convenient and is readily estimatable by standard econometric techniques. Pre-tests of nonlinear relationships using semi-log and double-log transformations showed that these models did not provide statistical fits of the data which were superior to a linear model. Hence, supply response is estimated using ordinary least squares (OLS).

Model Specification

Supply response models for annual crops in developed and developing countries are usually specified as a function of those variables for which the farmer can control. Since output levels are highly influenced by factors beyond farmers control, hectarage planted is most often considered a more appropriate variable. Hectarage planted is especially appropriate for cotton production in Kenya because cotton is grown in marginal areas under adverse conditions. Cotton production occurs in these areas primarily because the rainfall is inadequate to support Kenya's main cash crops of coffee and tea. Farmers average less than 10 hectares per household, with .5 to 2.0 hectares traditionally allocated to cotton. Despite the small land holdings, farmers are able to vary their land and other inputs in various proportions without realizing diminishing returns to scale. These factors suggest that a model specification with hectarage planted as the dependent variable is likely to yield a price elasticity of hectarage planted which is a good approximation for the price elasticity of planned output.[7] As a consequence, hectarage planted is used as the dependent variable to capture farmers' supply responsiveness.

Cotton production decisions are made in June and July, long after the government sets the market price for cotton, as well as those for substitute crops. Farmers therefore do not have to form any expectations about future output prices, but might experience technological and institutional constraints in the procurement of requisite inputs. These factors suggest that a variant of Nerlove's partial adjustment model is likely to capture the responsiveness of small Kenyan cotton producers.[8] Conceptual and empirically estimatable models are developed subsequently.

Since the price of cotton is set before planting time, cotton producers can easily formulate their desired output. Assuming that desired output is linearly related to price (PSC), a typical specification is as follows:

(1) $O_t^* = \beta_0 + \beta_1 PSC_t + e_t$

where O_t^* is desired output and PSC_t is the announced cotton price. Because desired output, O_t^*, is an unobservable variable, a Nerlove formulation suggests that it can be specified as

(2) $O_t - O_{t-1} = \delta(O_t^* - O_{t-1}),\ 0 < \delta \le 1$

where δ is the coefficient of adjustment, $O_t - O_{t-1}$ is actual change and $O_t^* - O_{t-1}$ is desired change. As specified, equation (2) postulates that the observed change from O_{t-1} to O_t is proportional to some fraction δ of the desired change for that period. Rewriting equation (2) as

(3) $O_t = \delta O_t^* + (1-\delta)\ O_{t-1}$

and substituting equation (1) into equation (3) gives

(4) $O_t = \delta\beta_o + \delta\beta_1\ PSC_t + (1-\delta)\ O_{t-1} + \delta e_t$

This is a simple version of the partial adjustment model and the parameters of this model can be estimated using OLS if the original e_t's are serially uncorrelated.[9]

Because output is influenced by many factors beyond farmers' control, hectares planted (HCT) are most often substituted for output in supply response models. Making this substitution and rewriting equation (4) in econometric form

(5) $HCT = d_0 + d_1\ PSC_t + d_2\ HCT_{t-1} + U_t$,

the short-and long-run elasticities can be easily derived. Using the OLS coefficients from the above equation, it is apparent that $\hat{\delta} = 1-\hat{d}_2$, $\hat{\beta}_o = \hat{d}_o/\hat{\delta}$, and $\hat{\beta}_1 = \hat{d}_2/\hat{\delta}$. The short-and long-run elasticities evaluated at the means are respectively $\hat{d}_2\hat{\delta}\left(\frac{\overline{PSC}}{\overline{HCT}}\right)$ and $\hat{d}_2\left(\frac{\overline{PSC}}{\overline{HCT}}\right)$. While equation (5) captures and depicts the methodological description of the Nerlovian adjustment model, its final form for empirical estimation must capture other relevant factors underlying the commodity of interest. Equation (6) includes other economic factors which impact cotton production in Kenya.

(6) $HCT = \beta_0 + \beta_1\ PSC + \beta_2\ PMA + \beta_3\ PSR + \beta_4\ PIT + \beta_5\ DVR + \beta_6\ HCTL + U$

where HCT = Hectares of cotton in production

PSC = Producer price of seed cotton

PMA = Producer price of maize

PSR = Producer price of sugarcane

PIT = Index of inputs prices

DVR = Dummy variable with 0 value for prompt payment, 1 for delayed payments

HCRL = Hectares of cotton in production lagged one period

$\beta_0 - \beta_6$ = Regression coefficients

U = error term

The prices of maize and sugarcane are included in equation (6) because they are alternative crops for small producers. Small farmers are hypothesized to decrease their production of cotton as producer prices of maize and sugarcane increase. Thus, negative parameters are expected for β_2 and β_3. An index of all agricultural inputs, PIT, is specified as a proxy for cotton production costs. As a result, a negative parameter was also hypothesized for β_4. The dummy variable, DVR, is intended to capture the effects of delayed payments to farmers, delays which reportedly started in 1976; these payment delays are hypothesized to have a negative impact on cotton production. A one year lag of cotton hectares (HCTL) is intended to represent the lag effect of economic behavior. That is, farmers' response to economic conditions is hypothesized to show a period of adjustment that peaks after one year. Finally, farmers are hypothesized to be rational producers and therefore increase cotton production as the price of cotton (PSC) increases.

As a preliminary test of farmers' responsiveness to price incentives, the annual production data for 1966-1983 were divided into pre- and post-price incentive periods and analyzed for mean yield differences. A t-test on mean yields for 1967-75 and 1976-83 showed no statistical differences in yields, suggesting that farmers respond to price incentives by varying their hectarage planted as opposed to their per hectare use of variable inputs. This decision method is quite plausible for Kenyan farmers because little technological advancement has occurred in cotton production. New varieties have been introduced, but these varieties have longer maturity periods and therefore overlap and compete with alternative crops. As a consequence, farmers have been slow to adopt new seed varieties.

Ordinary least squares (OLS) estimation of equation (6) yielded statistically insignificant parameters for all variables except producer price of maize (PMA), but a R^2 of .94. Such results suggest strong multicollinearity and perhaps some redundant explanatory variables. Correlation analyses on the explanatory variables revealed a correlation coefficient of .93 for seed cotton (PSC) and sugarcane (PSR) prices, but no significant correlation for any other variables. As a result, PSR was dropped and the model reestimated. This correction for multicollinearity led to statistically significant parameters for all variables except the dummy variable (DVR) shifter for delayed payments. With the sample size consisting of eighteen observations, DVR was also dropped to conserve degrees of freedom.

A reasonable explanation for the insignifance of DVR may be that a zero-one variable cannot capture the adjustment process of small farmers. That is, farmers may not make an immediate adjustment to payment delays, but adjust their expectations and planting decisions as a linear or nonlinear function of time. Additionally, the effect of the producer price of seed cotton (PSR) on planting decisions may be so pronounced that the effect of payment delays is minimized. This suggests a need to deflate PSC to reflect the real price of cotton as opposed to the announced government price.[10-11] Such adjustment is not made in this study because of unavailable data and information.

The final estimated model is a specified below in equation (7):

$$(7)\quad HCT = \beta_0 + \beta_1\ PSC + \beta_2\ PMA + \beta_3\ PIT + \beta_4\ HCRL + U,$$

where the variables are as previously defined.

Empirical Results

Estimated results from equation (7) are reported below in equation (8),

$$(8)\quad \underset{(-1.07)}{HCT = -17176.73} + \underset{(5.77)}{1321.75\ PSC} - \underset{(-2.66)}{1615.06\ PMA} - \underset{(-1.80)}{65.00\ PIT}$$

$$+ \underset{(1.98)}{.2436\ HCRL} \qquad R^2 = .93$$

where the numbers in parenthesis are t-ratios. All parameters are signed as hypothesized and each one is statistically significant at the 5 percent level or better. Serial correlation was insignificant as measured by the h-statistic and by the regression coefficient for U_{t-1}, when U_t was regressed on U_{t-1} and all other regressors. The h-statistic of -1.32 was not less than the critical h-value from the normal distribution table at the 5 percent level and the coefficient on U_{t-1} was equal to its standard error. Finally, a plot of the residuals showed no pattern of correlation. The Durbin-Watson statistic is not reported because it is inappropriate when a lagged dependent variable appears as a regressor. The h-statistic may also be inappropriate for this study because of the small sample size of eighteen observations, but clearly a regression of the error terms (U_t) on their lagged values and other regressors is an appropriate test of autocorrelation.

From a statistical viewpoint, the farm price of seed cotton is the most important factor determining cotton production. The estimated parameter suggests that a $1 increase in the real price of cotton would lead to an increase in planted production of 1322 hectares. As shown in Table 1, the estimated long-run elasticity coefficient suggests that a 1 percent change in PSC would lead to a 1.7 percent change in hectares planted. By comparison, the short-run elasticities suggests a 1.3 percent change in HCT for each 1 percent change in PSC. Short-and long-run elasticities for maize are -.48 and -.63 respectively. These coefficients suggest that cotton producers do switch relatively easily between production of the two commodities.

Table 1: Short-and Long-Run Supply Elasticities

Independent Variable	Elasticity of Cotton Hectarage With Respect to Price		Coefficient of Adjustment	Mean Value of Independent Variable
	Short Run	Long Run		
Cotton Price	1.33	1.75	.76	120.57
Maize Price	-.48	-.63	.76	35.44

The coefficient for input prices, although significant at only the 10 percent level, suggests that changing input prices do influence production. This limited effect is theoretically plausible because the major inputs used by small producers, family labor and land, are unaffected by input price changes. The estimated elasticity shows a .18 percent decrease in hectares planted for each 1 percent increase in input prices, and vice versa. The estimated parameter for lagged hectarage suggests that 76 percent (1-.24) of the adjustment toward long-run equilibrium occurs during the first year. This rapid rate of adjustment is theoretically plausible since most of the producers are small with limited fixed investments in cotton.

Not only are all the estimated parameters significant, but Figure 2 shows that the model as specified closely predicts actual changes in hectares planted. A dummy variable included in an earlier model to account for payment delays to farmers proved insignificant, an unexpected result. However, the sharp downturn in cotton production beginning in 1979 is easily explained by the significant change in the relative price of cotton to maize (Figure 3). As expected, dropping DVR led to improved t-ratios for all variables, but reasonably constant coefficients for these variables. Moreover, excluding the dummy variable served to improve predicted values relative to actual values. In sum, the estimated model is considered to be correctly specified based on its statistical significance and its ability to track historical values, including turning points.

Conclusions and Implications

Small farmers in Kenya responded to economic incentives to nearly double cotton production in just three years. Producer prices of cotton, maize, and the cost of inputs are statistically important factors which influence production. Cotton producers seem to easily shift from cotton production to maize as relative prices change. Moreover, the adjustment process toward long-run equilibrium seems immediate, with 76 percent of it occurring during the first year. Such rapid adjustment is theoretically plausible since small farmers have limited fixed investments in cotton production.

Given the ease with which small farmers switch from one crop to another, a sustained increase in cotton production will require cotton prices to remain competitive with those of alternative commodities. A close examination of the data shows that the real price of cotton peaked in 1978 and then fell 7% between 1978-79. Yet, the price of cotton relative to maize increased 3% during this period and farmers continued to increase cotton production. By 1980, the relative price of cotton to maize had fallen 10% and consequently, cotton production fell drastically.

Clearly the domestic industry has the capacity to meet its needs. Moreover, the supply responsiveness of small producers suggests that it can be done quickly because of the limited capital required to produce cotton. As the marginal utility of each dollar is likely to be quite high for small producers, the long-run adjustment process that characterizes these producers is likely to be far shorter than that which characterizes larger producers. Such rapid adjustment suggests that the government's objective of using cotton as an earner of foreign exchange can be achieved only if policies are implemented which maintain stability between cotton prices and those of other competing commodities.

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Figure 1. Cotton Production In Kenya

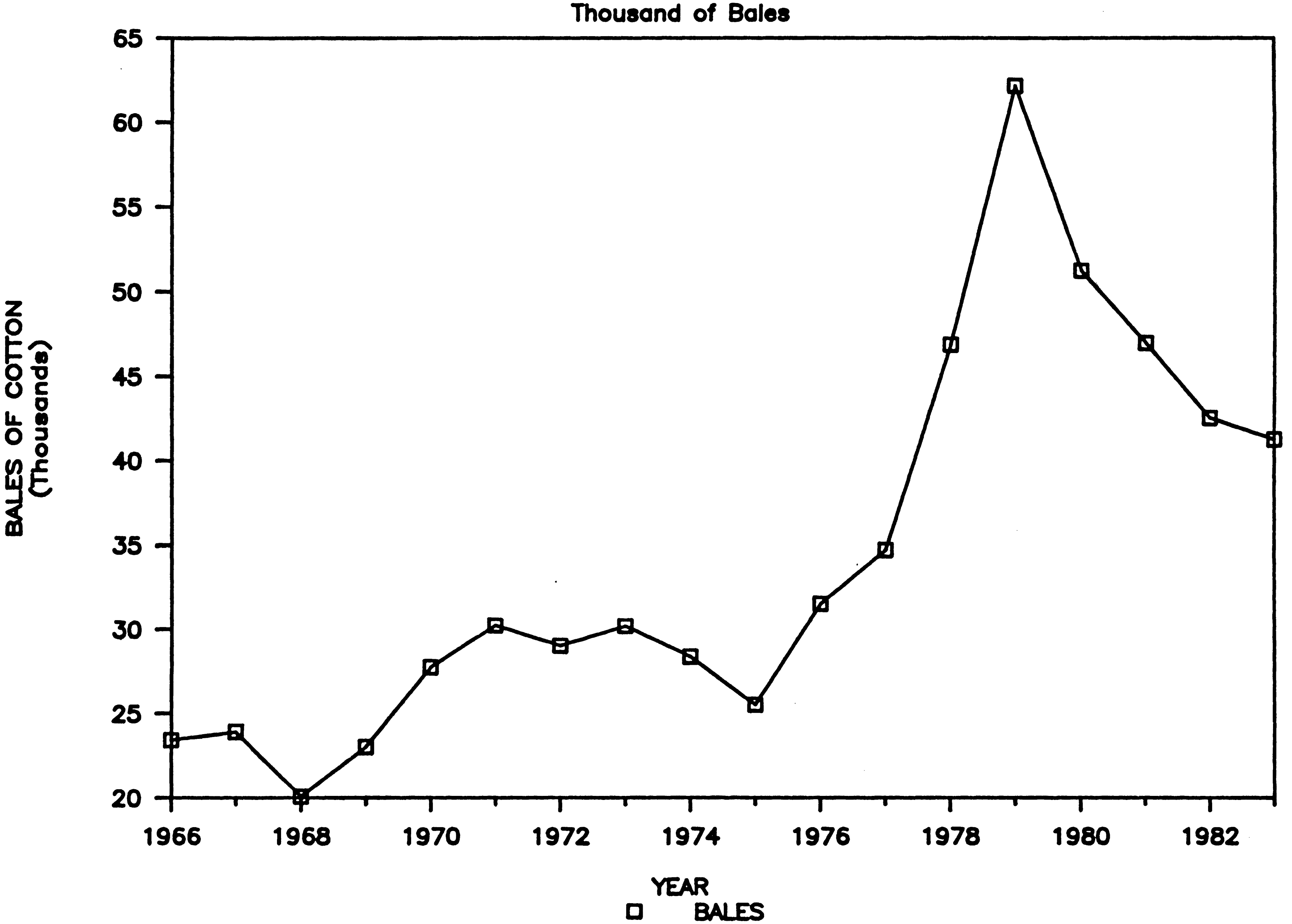

Figure 2. Actual and Predicted Values

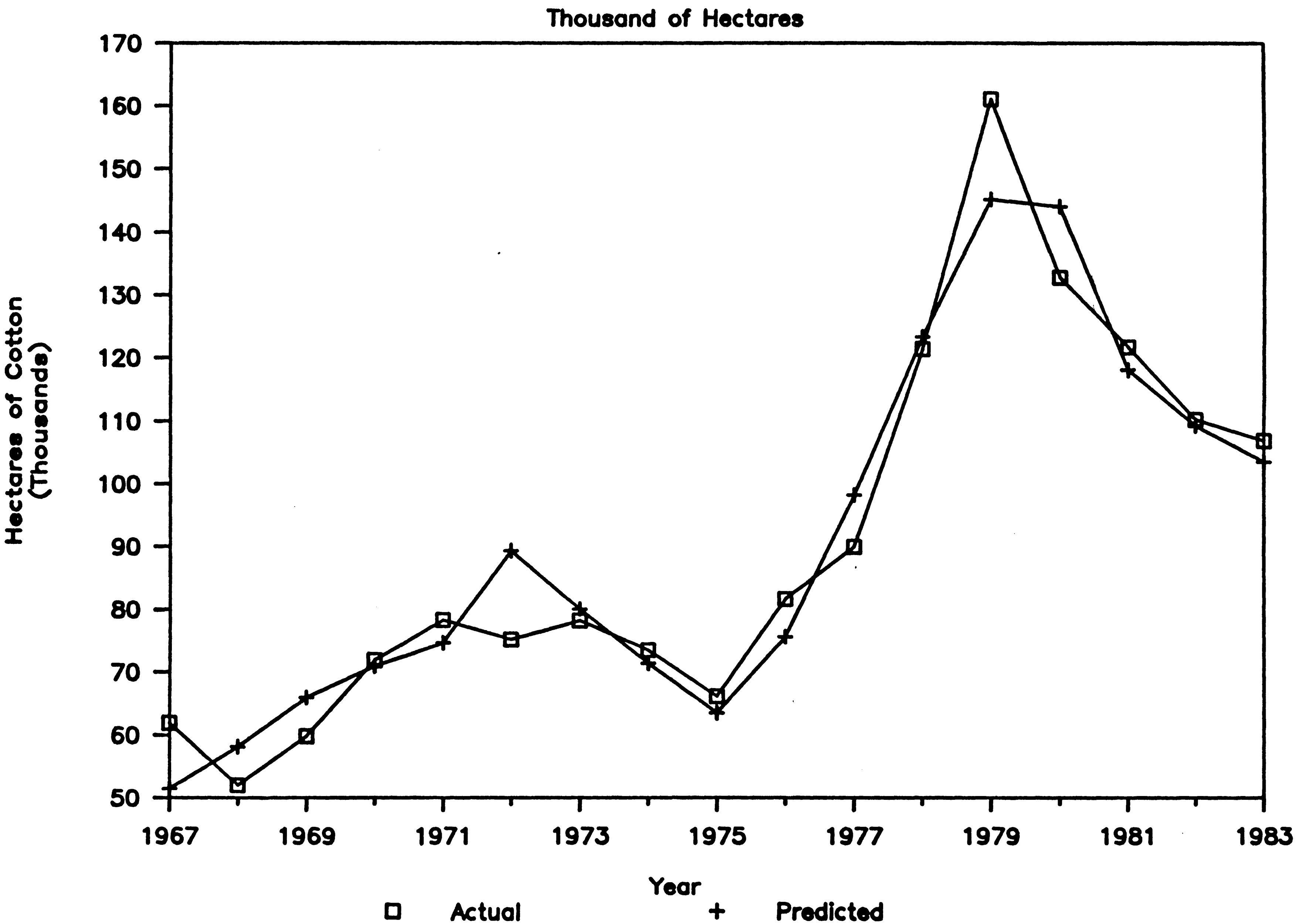

Figure 3. Prices of Cotton and Maize